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YIELD OF BAJRA(Pennisetum typhoideum) IN RELATION TO PLANT DENSITY.

K. C. SHARMA

Millets are most important annual grasses. They are grown under conditions where other crops do not thrive well, more so in regions of low rainfall. Out of the total area of 80 million acres under millets in India, Bajra is grown on about 24 million acres. It has special importance for the Agra tract as:—(i) the climate of the place suits the crop very well, (ii) the crop suits most for double cropping in the locality and (iii) it is the main food for the poor in the country side for about five months i.e. October to February.

Although the crop has been so important to West of Uttar Pradesh, it has not received much attention from research workers, both plant breeders and agronomists. In order to explore the potentialities of this crop, extensive research must be carried out.

The Indian farmer is poor and ill financed. He cannot afford sufficient manure and water for his fields. Of the cultural practices space allowed to each plant is one of the most important factor which controls yield. Ordinarily farmer in the countryside is not fully conscious of the effects of spacings on the plant growth and yield and is often neglectful to this aspect. He has ample cheap labour and therefore any recommendation which may need more labour but little cash investment will suit him most. Improved cultural practices such as proper spacing may easily be adopted by the Indian farmers. With this aim in view the present investigation, the effect of different spacings on growth, development and yield of Bajra" was planned and carried out at the Balwant Rajput College Experimental Farm Bichpuri, Agra during the Kharif season (July-Nov.) of 1954-55. The results of this work are discussed in this paper.

Procedure.

The farm enjoys a typical sub-tropical climate with hot summers and severe winters (maximum temperature 118° F and minimum 34° F). The average annual rainfall is 25" and is received mostly from July to September with exceptional showers in winters. The rainfall in the Kharif for the year 1954-55 was 19·54"

The mechanical and chemical analyses of the soil from the experimental plot were done and are given in the following table.

Table 1.

Mechanical and Chemical analyses.

Mechanical percentage on open dry soil (0-8″)		Chemical analysis (0-8″) %	
1. Coarse sand.	0·46	1. Total nitrogen.	0·043
2. Fine sand.	57·29	2. Total Phosphorus.	0·081
3. Slit.	21·75	3. Total Potash.	1·288
4. Clay.	19·50		

The above figures indicate that the soil was sandy loam in texture and low in nitrogen, while it was rich in phosphorus and potash.

Treatment combination and symbols

The treatment comprised of three spacings between rows and there spacings between plants as detailed below.

Three spacings	**between rows.**	**Three spacings**	**between plants.**
Treatments	Symbols	Treatments	Symbols
12 inches	S12	6 inches	D 6
18 inches	S18	12 inches	D12
24 inches	S24	18 inches	D18

In all there were 9 treatment combinations as follows :

1. S12 D6	4. S18 D6	7. S24 D6
2. S12 D12	5. S18 D12	8. S24 D12
3. S12 D18	6. S18 D18	8. S24 D18

The single split plot design with row spacing as main treatment was adopted. The desired plant to plant distance was maintained by thinning the crop 20th. days after sowing.

Stand of the crop was noticed at four different stages of the life cycle i. e. 20th, 40th, 60th and at harvest. It was taken by counting the total number of crop plants in each plot. Survival percentage was also calcuated for the last three stages.

Result and Discussion

Plant density at successive stages of growth

The comparison of the plant density at 20th day and at other stages shows that there was a decrease in stand under all treatments due to mortality. The percentage of decrease on an average from 20th to 40th day was 11·78. The decrease was greater in the treatments where the initial stand was higher. The minimum decrease of 1·35%, was observed in treatment S24 D18, while it was maximum (31·01%) where the treat-

ment S12 D6 was given. The trend in reduction of plant population from 40th day to 60th day was almost same as noted earlier. On an average a general decline of 2·44% was obtained at this stage. The highest and lowest figures being 3·44% and 2·11% respectively. The data recorded at harvest indicate, on an average, further reduction of 0·802% in the plant population. At this stage no reduction was seen in plots of S24 D18, while it was 1·608% in plot of S12 D6.

The statistical analyses of the survival percentages at various stages show that both row to row and plant to plant spacings were significant at all the stages, while their interactions were significant only at 60th day and at harvest.

Table II

Number of plants per plot at various stages.

Treatments.	20th day	40th day		60th day		Harvest.	
	Plant density.	Plant density	Survival percentage.	Plant density.	Survival percentage.	Plant density	Survival percentage.
1. S12 D6	864	596	68.94	575	66·58	563	65·73
2. S12 D12	432	377	87·21	367	84·26	359	83·78
3. S12 D18	288	239	82·81	232	80·55	230	79·68
4. S18 D6	576	477	82·75	468	80·77	462	80·46
6. S18 D12	288	264	91·49	257	89·06	204	88·19
6. S18 D18	192	178	92·44	174	90·75	174	90·62
7. S24 D6	432	404	93·51	398	91·89	394	91·14
8. S24 D12	216	208	96·17	206	94·19	202	93·51
9. S24 D18	144	142	98·65	139	96·50	139	96·50
C. D. 5%			Non. Sig.		Sig. 2·64		Sig. 6·62

Table III indicates that S24 had significiantly higher survival percentage than S18 and S12 at all the stages of observation. Similarly it is clear from the table IV that survival percentage was significantly higher with D18 and D12 than with D6.

Table III

Row spacings and Survival percentage.

Treatments.	20th day Plant density.	40th day		60th day		Harvest	
		Plant density.	Survival percentage.	Plant density	Survival percentage.	Plant density.	Survival percentage.
1. S12	528	403	79·6	391	77·1	383	76·3
2. S18	352	305	88·8	299	86·8	280	86·4
3. S24	264	251	96·1	146	94·1	144	93·7
C. D. 5%			Sig. 5·08		Sig, 4·04		Sig. 3·13

Table IV

Plant spacings and survival percentage

Treatments	20th day Plant density.	40th day		60th day		Harvest	
		Plant density.	Survival percent-age.	Plant density	Survival percent-age.	Plant denstiy	Survival parcent-age.
1. D6	624	492	81·7	476	79·7	386	79·1
2. D12	312	285	91·6	275	89·1	253	88·5
3. D18	208	185	91·3	181	89·2	180	88·9
C. D.			Sig. 4·62		Sig. 2·61		Sig. 3·89

Obviously mortality percentage was greater where the intitial stand was higher. In spite of this, the final stand left over was more in close spaced plots This indicates that the space allowed to each plant affected survival percentage through out the crop growth. The competition between the plants in plots of S24 and D18 must have been the least and hence less mortality. On the other hand the lowest percentage of survival in thickly populated plots (S12 and D6) may be attributed to keen competition in plants.

A number of persons in India and abroad working on these lines have concluded that heavy losses due to poor survival percentage in closely spaced plots occur. Jethrotul (1930) inferred that of about 10 seeds of winter corn sown one might be expected to give a plant at harvest. Engledow and Ramiah (1930) reported that under good conditions seed germination in paddy is 80 to 90 percent and that only 60 to 80 percent survive upto harvest. Russel and Watson (1940) reported that from old times, farmer expected only about 40 percent of the seed to produce grain bearing plants. Jacobson (1915) studying the influence of area per plant on yield of grain in rice observed that higher death rate of seedlings prevail in close spacings than in a more widely spaced ones.

Yield of grain and Karabi per acre.

Grain :—Table V indicates that S12 produced the maximum grain yield per acre followed by S18 and S24 respectively. The differences as between them were, however, non-significant.

Table V

Row spacings and grain and Karabi in Mds. per acre.

Treatments.	Grain Yield.	Karabi Yield	Grain and Karabi Ratio
1. S12	15·06	45·17	0·33
2. S18	13·90	42·00	0·33
3. S24	12·60	34·50	0·37
C. D. at 5%	Non-Sig.	Sing. 7·92	

Amongst plant spacings D6 and D12 were significantly better than D18 with respect to grain yield per acre. The variation as between D6 and D12 was also significant and improved grain yields were obtained where six inches spacing was adopted.

Table VI

Plant spacings and grain and Karabi in Mds. per acre.

Treatments	Grain yield	Karabi yield.	Grain and Karabi ratio.
1. D6	15·30	46·87	0·32
2. D12	13·90	40·25	0·34
3. D18	12·40	34·60	0·36
	Sig.	Sing.	
C. D. at 5%	0·72	5·39	

An examination of table VII will reveal that S18 D6 and S12 D12 produced higher grain yield per acre followed by S24 D6. It may be stated here that the treatments S24 D6 and S12 D12 were identical in nature so far number of plants per acre are concerned, but the yield potentiality of the two were different.

Table VII

Grain and Karabi Yields in Mds. per acre.

Treatment.	Grain Yield			Karabi Kield.		
	D6	D12	D18	D6	D12	D18
1 S12	13·4	16·5	14.8	45·0	48·5	41·0
2. S18	16·6	13·0	11·9	49·6	41;8	34·7
3. S24	15·5	11·9	10·6	45·0	30·8	27·9

Higher yields were noted for S12 D12 than S24 D6 (table VII) similarly S18 D12 and S12 D18 had the equal plant population but greater yield was obtained with S12 D18. This shows that the struggle for existence among plants is greater with in the row rather than in between the rows.

Karabi :—With lesser spacing, both between rows and within rows, an increase in the produtcion of Karabi (table V and VI) was noted. S12 produced significantly greater yield per acre than S24, but the yield difference for S18 and S24 was not

appreciable. With increased plant spacings, the Karabi yield was reduced. The maximum production was obtained where 6 inches spacing was given. The variations as between D6 and D12, D6 and D13 and D12 and 18 were all statistically significant.

The above results agree with that of Doughty and Engledow (1928), who concluded a high correlation between number of plants at harvest and yield per foot in wheat. Haigh (1938) and Brayan et al (1940) working on paddy and corn respectively obtained greater yield with narrow spacings, while Huelson (1943) reported the positive correlation between number of plants per acre and yield.

Grain to Karabi ratio :–Table V indicates that grain to karabi ratio was higher under S24 followed by S12 and S18. However, the latter two did not differ from each other. For plant spacings the grain to karabi ratio was higher with D18 followed by D12 and D6 (table VI). Here again it may be concluded that space allowed to each plant affected the grain to karabi ratio, may be due to the fluctuation in survival percentage.

From the foregoing discussion it may be concluded that the crop yields are not as much affected by row to row spacings as are affected by plant to plant spacings within the rows. For the maximum yield, bajra may be sown either at a row to row distance of 12" with the same spacing within the row or at a row to row spacing of 18" with 6" plant to plant distance.

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RESPONSE OF WHEAT Pb. 591 TO THE VARIATIONS IN LEVELS OF NITROGEN AND IRRIGATION

S. C. Modgal

Introduction

In the arid plains of Indo-Gangetic Alluvium nitrogen supplies and irrigation are considered to be the main factors affecting the yield of grain crops in general and wheat in particular.

Series of investigations have shown a general deficiency of nitrogen in Indian soils ; the light textured soils of arid regions are the typical examples. Stewart (1947) and Anonymous (1953) have stressed the need for nitrogenous manuring in some form or the other.

All the efforts to increase wheat production will not be fruitful even with sufficient supplies of available nitrogen unless optimum conditions of soil moisture are met through irrigation whenever it is needed. Thus to have a judicious combination of nitrogen and irrigation to produce wheat at it's maximum in Agra-region the present investigation was undertaken.

Experimental Technique

At the B. R. College Agricultural Experiment Station, Bichpuri, Agra, a 'single split plot' field experiment was laid out in the *Rabi* season (November to April) of 1957-58 to test the effect of four levels of nitrogen (0, 20, 40 and 60 lb. N/ Acre) and three numbers of irrigation (Heavy 5 ; Medium-3 ; and Low-1 irrigation). Thus there were 12 treatment combinations which were replicated four times. Nitrogen was applied through ammonium sulphate broadcast just before sowing. The experimental crop of wheat which was sown on November 19, was taken after Juar (*Sorghum vulgare*) during the preceding *Kharif* season.

Summer precipitation in that year was 31.95", which was considerably higher than the average. This increased precipitation caused a rise in the ground water-table. However, winter months were totally dry which had only a precipitation of 0.63" (November to April).

The soil samples taken before applying the manures, from the experimental area were subjected to chemical and mechanical analysis. The soil was found to contain 0.046% nitrogen and was sandy loam in texture. The grain and straw (*Bhusa*) yields per acre were statistically analysed.

Results And Discussion

The yield data for grain and straw (*Bhusa*) obtained are given in Table 1. Some of the chief yield contributory factors which are of interest in the discussion, have been presented at the end in the Appendix.

Table 1.

Yield of wheat grain and straw (*Bhusa*) in Md. / Acre for four levels of nitrogen and three numbers of irrigation.

Treatments	Grain	Straw (*Bhusa*)
Levels of nitrogen		
No nitrogen	4.56	11.33
20 lb. / Acre	9.05	25.00
40 lb. / Acre	10.72	34.30
60 lb. / Acre	12.20	38.55
S.E.	±0.96	±2.63
C.D. at 5%	2.78	7.61
Numbers of irrigation		
Low	6.82	21.18
Medium	8.48	26.64
Heavy	12.11	34.06
S.E.	±1.27	±2.92
C.D. at 5%	Non. sig.	Non. sig.

In general yields under all treatment conditions were found poor (Table 1). This may chiefly be attributed to the late sowing of crop, failure of winter rains and also the low soil fertility of the experimental plot which have already been described above in the Experimental Technique. These factors have also affected different yield contributory plant characters (Appendix Table).

In this study variations noted for yiled were quite distinct and that due to nitrogen were significant. The main and interaction effects due to various treatments are discussed below :

Main effects :

(a) *Levels of nitrogen :*

With every increase in the levels of nitrogen an increase in the yields of

both grain and straw (*Bhusa*) was obtained. The variations in between the grain yields obtained for 20 lb. and 40 lb. and 40 lb. and 60 lb. dose were statistically non-significant. While the 60 lb. dose failed to increase the grain yields significantly over 40 lb. dose, the variations obtained due to 60 lb. and 20 lb. dose were statistically significant. With an increase in nitrogen level up to 40 lb., there was a significant increase in the straw yields of wheat. But above this dose (40 lb. nitrogen) the increase in straw yield was non-significant. It may be stated here that with 40 lb. rate of nitrogen application, the improvement in yield contributory factors was the maximum (Appendix Table). Thus considering the effects on both yield and yield contrtbutory factors, such as grain yield per plant, dry weight per plant and ear-bearing tillers per plant, the treatment 40 lb. rate appears to be the best.

Rao et al. (1957) working at the same station have also reported the similar results. In these experiments they did not get significant increases in wheat yield above 40 lb. nitrogen applications.

(*b*) *Numbers of irrigation* :

The results in Table 1 show an increase in yields for grain and straw (*Bhusa*) with every increase in the number of irrigations. But the differences were not appreciable and were found statistically non-significant. It may be argued here that in 1957-58 due to heavy rainfall in the *kharif* season, the ground water table was raised considerably and possibly this might have kept the soil wet during *Rabi* season. The non-significant effects due to irrigation levels may be accounted for this reason. The trend however indicates the beneficial affects of increased irrigation and the best yields were obtained with the heavy (5 irrigations) irrigation.

Interaction effects :

Levels of nitrogen × numbers of irrigation.

Table 2.

The yield of straw (*Bhusa*) in Md / Acre for the significant interaction : levels of nitrogen × numbers of irrigation.

Nitrogen / Irrigation	0 lb.N/Acre	20 lb. N/Acre	40 lb. N/Acre	60 lb. N/Acre.
Low	9.82	17.15	30.27	27.47
Medium	11.22	20.90	25.75	48·70
Heavy	12.95	36.97	46.87	39.47

Interaction Nitrogen × Irrigation ± S. E. 4.56

A critical examination will indicate that the higher doses of nitrogen responded better with either medium or heavy irrigations. With low irrigation, straw yields

were considerably reduced even where 60 lb. nitrogen was applied. Production of straw with 40 lb. nitrogen in combination with heavy irrigation may be regarded as good as produced by 60 lb. nitrogen along with medium irrigation. The performance of nitrogen levels lower than 40 lb. N under all the irrigation treatments was poorer than 40 lb. nitrogen and heavy irrigation. This shows that for wheat straw, 40 lb. nitrogen with five irrigations may be considered the optimum.

Summary And Conclusion

This experiment was conducted at the B.R. College, Agricultural Experiment Station, Bichpuri, Agra in the *Rabi* season of 1957-58 to study the effects of nitrogen (0, 20, 40, and 60 lb./Acre), increasing number of irrigations (1, 3, and 5 irrigation) and their interactions on grain and straw (*Bhusa*) yields of wheat, Pb. 591. Following are the conclusions which may be drawn out of the results obtained.

1. Wheat crop responds to nitrogen application significantly and a dose at the rate of 40 lb. nitrogen per acre seems to be the best for grain and straw (*Bhusa*) production.

2. With the increasing levels of irrigation some improvement in the grain and straw yields was obtained, but the increases were statistically non-significant. However, the maximum yield was produced with five irrigations (Heavy).

3. Interaction effect (Nitrogen x irrigation treatments) was significant on straw yield of wheat. 40 lb. nitrogen and five irrigations may be a good combination and may be recommended to the cultivators for adoption.

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Appendix Table

Data on yield contributory factors (averages).

Treatment	Yield of grain/ plant in gm.	Dry weight/ plant in gm.	Numbers of ear bearing tillers / plant at harvest
Levels of nitrogen.			
No nitrogen	2.15	5.96	2.56
20 lb. N/Acre	4.27	10.71	3.56
40 lb. N/Acre	5.15	12.10	3.83
60 lb. N/Acre	4.67	11.64	3.65
Numbers of irrigation.			
Low	3.39	8.16	4.55
Medium	4.03	10.21	4.33
Heavy	4.76	11.93	4.73

EFFECT OF PLANT REGULATORS AND THEIR METHODS OF APPLICATION ON PARTHENOCARPY IN WATERMELON

D. MAHARANA and S. M. SINGH

To consumers as well as producers of many fruits and vegetables, seedlessness has always been a coveted ideal. Since the discovery of plant regulators various attempts have been made to find out practical methods of their application for reduction in number of seeds. This is of a special importance in a crop like watermelon in which seeds are embedded in the edible flesh.

The best result was obtained by application of plant regulators by paste method (3). Strong (8) modified the method of Gustafson (3) of applying lanolin paste by merely cutting the buds or recently opened flowers close to the ovary. Hilton (4) secured parthenocarpic tomatoes by applying alpha-naphthaleneacetic acid (NAA) and indole –3– butyric acid (IBA) in lanolin paste in concentrations ranging from 0.01% to 5.0%. Singh and Kacker (7) produced complete seedless tomatoes by this method The commercial application of plant regulators by paste method is, however, very limited because individual flowers have to be treated.

Gardner and Marth (2) obtained parthenocarpic fruit in a number of species by spraying plant regulators in aqueous solution. Konhar (6) produced parthenocarpic fruits in Tinda (*Citruilus vulgaris* Schard var. *fistulosus*) by aqueous spray of NAA. Spraying too has its limitations because the duration of flowering in watermelon is long and a number of applications has to be made to ensure that each flower has received the plant regulator. A method was suggested by Gardner and Marth (2) that dry chemical be injected in the stem of the plants. This method has not received much attention as yet, though this appears to be the easiest and most practical method of applying plant regulators on large scale. It was, therefore, thought desirable to find out the efficacy of this method in comparison to paste and spray methods with different plant regulators.

Experimental procedure

Plant regulators used in this experiment were IBA, NAA and their 50 : 50 mixture. Each one of these was applied by three methods, injection, spray and

paste, and one set was kept as control. . This gave ten treatment combinations and each was replicated four times. The concentration of plant regulator in lanolin paste was kept at 0.5%, in spray at 500 p.p.m., and in the injection 0.025 gm. of dry chemical was injected in the stem of each plant at the base.

Watermelon seeds were sown at a depth of 1" on one side of 1½' wide furrows on 9. 1. 1959 at a distance of 3' beetween plant and 8' beetween rows. Net plot was 12'×8' with four plants in each. The experiment was laid out by randomised block design.

Experimental findings

Effect of method of application of plant regulators :

(a) *Fruit Characters :*

The method of application of plant regulator had a highly significant effect on the important fruit characters (Table I). It was found that when the flowers received no treatment, 45.2% of female flowers set fruits. This was reduced to 36.5% when the dry chemicals were injected in the main stem of the plants, and further reduced to 13.6% when the chemicals were sprayed in water solution. Under paste method none of the female flowers set fruit. Along with the reduction in the percentage of fruit set the size of the fruits as judged by their weight and volume was also very significantly reduced as a result of the application of plant regulators, and here again spray reduced it more than injection. As compared to control the size of fruits was reduced to about half under spray. In respect of the quality of the flesh of the fruits, on the other hand, the effect was just the reverse. The percentage of dry matter in the edible flesh as well as non-reducing sugars increased significantly by the application of plant regulators, and spray was more effective than injection. Fruits treated with plant regulators, however, took longer time to reach maturity in comparison to the untreated ones and the delay in maturity was greater in spray.

Table I

Effect of method of application of plant regulators on fruit characters.

Methods	Percentage of fruit set	Weight per fruit (lb)	Volume per fruit (liters)	Percentage of dry matter in the flesh	Percentage of non-reducing sugars in the flesh	No. of days for maturity
Control	45·2	24·8	11·3	6·96	2·42	30·2
Injection	36·5	19·7	10·0	8·59	3·18	33·7
Spray	13·6	12·0	6·5	9·59	4·31	36·5
Paste	0·0	—	—	—	—	—
C. D. at 1%	11·4	3·54	1·35	1·09	0·26	2·59
„ „ 5%	8·5	—	0·98	0·80	—	—

The percentage of reducing sugars as well as the density of the fruits were not much affected by the application of plant regulators by any of the two methods in comparison to control.

(*b*) *Seed characters* :

The number, weight and volume of seeds per fruit were markedly reduced as a result of the application of plant regulators, and spray was much more effective than injection in this respect (Table II). The number of seeds was reduced from 1022 to 370 when the flowers were sprayed with plant regulators. On the weight and volume basis the seed content was reduced to even less than one third.

Table II

Effect of method of application of plant regulators on seed characters.

Methods	No. of seeds per fruit	Weight of seeds per fruit (gm.)	Volume of seeds per fruit (c. c.)	No. of seeds per pound of fruit
Cntrol	1022	184	178	41·9
Injection	683	120	115	34·9
Spray	370	53	53	29·7
C. D. at 1%	134	30·2	35·0	—
,, ,, 5%	—	—	—	7·3

Since the size of the fruits and their seed content were both reduced by the application of plant regulators, the effect of methods of application was studied on the seed content of fruits on equal weight basis. It was interesting to find that the number of seeds per pound of fruit was significantly reduced from 41·9 to 29·7 under spray.

Effect of plant regulators

The two plant regulators and their mixture tried in this experiment had a significant effect only on seed content of fruits and the number of days required by the fruit for reaching maturity after the opening of flowers. Various fruit characters including their size and quality as well as fruit set did not differ much under the three kinds of plant regulators.

NAA was much more effective than IBA in reducing the seed content of the fruits, and the mixture of the two plant regulators was intermediate in its effect (Table III). In the mixture NAA appears to have exercised greater influence than IBA, since the difference between the mixture and IBA was significant whereas that between this and NAA was not very marked. The fruits produced under IBA

matured about 3 days earlier than those of NAA. Here again the difference between NAA and mixture was not significant.

Table III

Effect of plant regulators

Plant regulators	No. of seeds per fruit	Weight of seeds per fruit (gm.)	Volume of seeds per fruit (c. c.)	No. of days for maturity
IBA	648	113	102	33·5
NAA	428	70	68	36·6
IBA+NAA	504	76	77	35·1
C. D. at 1%	164	34·5	—	3·1
,, ,, 5%	119	27·1	33·1	2·3

Discussion

In the present experiment spray method was superior to injection in reducing the seed content of fruits while paste method was a complete failure. Non-setting of fruits under paste may be due to the injury received when the styles were cut or due to the injurious effect of the paste or perhaps due to both. Wong (10) found that IBA and NAA of 0.5% to 1% strength applied as lanolin paste did not induce parthenocarpic fruits in commercial varieties of orange even though natural parthenocarpy existed in this type. When the plant regulators were injected at the base of the plant, their effect became less marked by the time they reached the flowers. In case of spray individual flowers were sprayed directly and hence the effect was much better. It was very interesting to find that the quality of fruits improved further by an increase in the percentage of dry matter and non-reducing sugars in the edible flesh as a result of application of plant regulators by these methods. Janes (5) found that artificially produced parthenocarpic tomatoes were superior in starch and total sugars than the normal ones.

The reduction in seed content was associated with a reduction in the size of fruits, the method giving the most seeded fruits yielded the biggest fruits also. Singh and Kacker (7) found that the average weight of seedless tomato was 27 gm. in comparison to 45 gm. of seeded ones. Fruits produced parthenocarpically were slower in their development in comparison to the normally pollinated ones and those of injection reached maturity earlier than the sprayed ones. Swarbrick (9) reported that fruit development was delayed by 3 weeks as a result of spray application of NAA put on full flowers. A delay of maturity has also been reported by Clark and Kerns (1) in pineapple.

NAA was the best followed by the mixture and IBA respectively for reduction of seeds. Gardner and Marth (2) sprayed the ovaries with aqueous solution of several substances of which NAA was found to be most effective. Konhar (6) found that NAA was more effective than IBA in reducing seed content of Tinda fruits.

Summary

Application of plant regulators was very effective in reducing the seed content of fruits in watermelon. Spray method was most effective since the number of seeds per fruit in this case was only 370 in comparison to 683 under injection and 1022 under control. Paste method was a complete failure because none of the treated flowers set fruit. Along with reduction in seeds there was a marked improvement in the quality of fruits since the percentage of dry matter in the edible flesh increased from 6.96 of untreated fruits to 9.59 under spray and that of non-reducing sugars increased from 2.24 to 4.31.

The size of fruits and their seed content were positively correlated in this investigation. The untreated fruits which had about three times greater seed content in comparison to the sprayed ones were about double in size. The injection method was intermediate in its effect. Application of plant regulators was also associated with a reduction in the percentage of fruit set and an increase in the number of days required by the fruits for reaching maturity. In these respects also the effect of spray was more marked than that of injection.

The size and quality of fruits were not much affected by the kind of plant regulators used, but in reducing the seed content of fruits, NAA was significantly better than IBA as well as the mixture of the two. The fruits under NAA, however, took three days more to reach maturity in comparison to IBA.

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EFFECT OF PLANT REGULATOR, AGE OF SHOOT AND TIME OF OPERATION ON AIR-LAYERING IN MANGO (*MANGIFERA INDICA LINN.*)

K. N. DUBEY, R. R. MAITI and S. M. SINGH

In India mango is commercially propagated by approach grafting (inarching) which involves two plants—the rootstock which constitutes the root system and the scion which forms the top or shoot. Advancement of knowledge in the field of plant propagation has now established that the rootstock influences the vigour and stature as well as the performance of the resulting plant. The Malling series of apple rootstocks have been evolved to control these characters. Mango, being the most important fruit of India, needs a similar series of standardized rootstocks. In some countries polyembryonic varieties of mango produce uniform seedlings which may be used for this purpose. Unfortunately, most of the varieties in India are monoembryonic (2). Thus, the only way left for commercial propagation of uniform rootstocks in this country is through rootage.

So far it has not been possible to propagate mango successfully by cuttings. However, by using branches of 2 to 3 years old trees and applying 1% indoleacetic acid Thakurta and Dutta (6) could raise plants from 80% of the air-layers. Since a small tree of 2 to 3 years can supply only a limited number of layers, Singh (3) conducted an experiment on layering of mature trees of several varieties of mango categorising then into vigorous, semi-vigorous and dwarf groups in order to get larger numbers of layers from a single tree. Maximum percentage of rooting was obtained from semi-vigorous group in which Kala, Anfas,Rataul and Dasheri were included. Of the various plant regulator treatment 1% alpha-naphthalene acetic acid produced the best result in this experiment, and shoots about 2 years old responded better than did those twice that age. Singh, Garner and Hatcher (5) also found that rootability decreased with the advancement of age of the shoot. It was, therefore, thought desirable to try branches of different age for layering. Commercially layering is done in the rainy season, i.e., in July and August in the northern parts of India, but even in the same season success depend largely on the actual time of operation and it is very necessary to find out the correct time to get maximum rooting.

In the semi-vigorous group Bombay green variety has been found to do well

under the climatic conditions of Agra region. Besides its possibility as a rootstock successful layers may be tried for orchard plantation.

The experiment described in this paper was conducted on Bombay green mango to test the suitability of plant regulator treatment and to find out the proper age of the shoot and time of layering to achieve high percentage of success in air-layering.

Materials And Methods

The layout of the experiment was randomised block with four replications. There were 12 treatment combinations (3 times of operation $\times 2$ ages of shoot $\times 2$ concentrations of indole-3- butyric acid) and thus 12 plots—a group of 10 layers constituting a plot—of each replication were laid out on one tree.

The layering operation consisting of the removal of $1\frac{1}{2}$ inch ring of bark along with the cambium, was done on three occasions from 11th July to 15th August at fortnightly intervals on two types of shoots, i.e. one year old and three year old. Half of the ringed shoots were treated with 1 per cent IBA in lanolin paste, the other half only smeared with lanolie to serve as control. The rooting medium was moist sphagnum moss. This was covered with gunny pieces, then wrapped with polythene (500 gauge $9'' \times 9''$ pieces) and tied with string.

The layers were separated 70 days after the operation when they were recorded for the various rooting characters including percentage of success.

Results

Layers that had rooted and were alive at separation were considered as successful, where as all the rooted ones whether dead or alive gave the percentage of rooting.

Third week of July proved far superior to the later dates for the success as well as rooting of layers (Table I).

Table I

Effect of time of operation on the percentage of success, percentage of rooting and number of roots per layer.

Time of operation	Percent success	Percent rooted	Number of roots per layer
Third week of July	64·4	65·0	5·2
First week of August	46·3	46·9	5·7
Third week of August	41·9	45·6	3·7
C. D. at 5%	5·41	13·81	1·46
C. D. at 1%	7·11	18·15	1·94

When thc opperation was delayed by a fortnight to the first week of August, there was a marked reduction in the percentage of layers rooted as well as rooted and alive (successful). Further delay was also associated with a reduction in these respects but the differences between the two dates of August were not much marked. In respect of the number of roots per layer, on the other hand, the first two dates of operation did not differ much among themselves but both were far superior ty the last date of operation.

Age of the shoot influenced the success, rooting and length of the roots significantly (Table II). Three year old shoots gave much better performance than one year old ones. The success was 43·8 percent when the operation was done on one year old shoots but this increased to 57·9 percent when three year old shoots were used. The trend was similar in respect of rooting and length of roots.

Table II

Effect of age of shoot on percent success, percent rooting and length of roots.

Age of shoot	Percent success	Percent rooted	Length of longest root in cm.
One year old shoot	43·8	45·0	4·13
Three year old shoot	57·9	58·3	5·56
C. D. at 5%	—	11·30	—
C. D. at 1%	5·79	14·86	0·834

The results obtained by treating the layers with 1 percent IBA did not differ significantly from those obtained without any treatment of the plant regulator.

The effect of the interaction between the age of shoot and plant regulator treatment on the percentage of success was very interesting. Three year old shoots gave significantly better results than one year old ones with as well as withoul plant regulators treatment, but the difference between the two type shoots was much less marked when they were treated with the plant regulator (Table III). The younger shoots showed some beneficial effect of the application of plant regulator, whereas, in the case of a older ones those not treated with plant regulator did better.

Table III

Effect of interaction between the age of shoot and plant regulator treatment on the percentage of success.

Plant regulator	Age of shoot	
	one year old	Three year old
Control	40·8	61·7
One percent IBA	46·7	54·2
C. D. at 5%		6.25
C. D. at 1%		8.21

The average effect of all the tteatment combinations regarding success has been given in Table IV. It is evident from this table that the best result (77·5 per cent) was obtained when the operation was in the third week of July on three year old shoots without any treatment of IBA. This was more than double of that obtained from one year old shoots in the month of August under the same treatment.

Table IV

Percentage of success obtained under the various treatment combinations.

Treatments	One year old shoot		Three year old shoot	
	Control	1 percent IBA	Control	1 percent IBA
Third week of July	500	60·0	77·5	70·0
First week of August	35·0	42·5	57·5	50·0
Third week of August	37·5	37·5	50·0	42·5

Interaction not significant

Discussion

Singh and Teotia (4) emphasized the importance of time of operation in mango layering. They observed that the success was much better inthe rainy season than in the spring. The results of the present investigation have shown that even in the rainy season the actual time of operation influences the success to a considerable extent. Layering done on Bombay green variety of mango during the third week of July produced far superior results than that in the first or third week of August. Similar results were also obtained by Garg (1). The humidity of the atmosphere and the frequency of rainfall are the chief factors that influence the success. A high humidity accompanied with frequent rains appears to be the ideal condition for air-layering in mango.

Working with two year and four year old shoots of several varieties of mango Singh (3) concluded that two year old shoots could be induced to strike roots readily by the application of growth regulating substances. In this experiment one year old sooots benefitted considerably by the application of IBA while the three year old ones not only failed to take advantage of the treatment but a significant decrease in the result was also noticed. The more active physiological stage of the former appears to make them respond to the external stimulus readily. The maximum success was, however, obtained under control when three year old shoots were used. This shows the inefficacy of IBA on older branches.

Summary

An experiment investigating the response of one and three year old shoots of mango, layered on three dates at fortnightly intervals from 18th July 1959, to plant regulator treatment is described.

The roo ing and survival of the layers were the best when the operation was done in the third week of July. With delay in layering the success was markedly reduced. Three year old shoots gave much better results than the younger ones. The overall effect of the plant regulators treatment was not significant but the interaction between the age of shoot and plant regulator treatment showed that the two types of shoots reacted differently to the treatmeht with one per cent IBA. The younger shoots showed some benefit from this treatment whereas in the older ones the success was significanty reduced.

The best result giving 77.5 per cent rooted and alive layers was obtained when the operation was done in the third week of July without any plant regulator treatment.

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NUTRITIVE VALUE OF *JOWAR* (*ANDROPOGON SORGHUM*) AS A CATTLE FEED WHEN SUPPLEMENTED WITH CALCIUM CARBONATE.

G. S. Rajorhia, V. N. Bhargava and S. N. Singh

Introduction

Green Jowar as a cattle feed occupies a key position amongst the popular feeds in the country. Besides its high palatability, it has been reported to be of great nutritional value (Lander and Dharmani, 1936; Sen, 1946 and Bindal, 1958). Balance experiment in this laboratory indicated that green Jowar as a single maintenance feed for buffaloes is highly economical and is able to meet out their requirements for protein, energy and phosphorus, but has been found to be deficient in respect of calcium (Rajorhia et al., 1959). Negative balances of calcium have also been reported by Iyer (1935) in whose case two out of three bullocks showed negative balances of CaO when kept on Jowar fodder alone. However, studies by Rao (1949) revealed the intake of calcium through Jowar straw ration alone to be adequate for the maintenance of buffalo bulls. This deficiency in Jowar may be present only on a regional basis associated with soil heterogenity influencing the composition of water and fodder supplied to the animals, nevertheless, an endevaour to make good this defi iency will be of great practical significance to make this fodder complete as a single maintenance feed. With this aim in view, a balance experiment to study the effect of calcium supplementation on the nutritive value of Jowar fodder was carried out.

Experimental Technique

The metabolic studies were conducted on three almost uniform male buffaloes with an average body weight of 680 lbs, which were previously kept on Jowar fodder alone for about 45 days during which a balance trial was also carried out (Rajorhia et al., 1959). On the basis of he negative calcium balances obtained in this trial and assuming the assimilability of calcium from calcium carbonate to be 50% the necessary amount of $CaCO_3$ required for supplementation was calculated. Every day the requisite quantity of $CaCO_3$ mixed with a small quantity of the chaffed fodder was supplied to the animals separately in enamelled basins. No fodder was served to them until they had quantitatively consumed the whole of the calcium carbonate. *Ad lib* feeding of the animals with chaffed Jowar fodder from the same

field as that of the previous trial was maintained throughout the experiment. This preliminary feeding was continued for 20 days which was followed by a collection period of 19 days. During the collection period representative samples of faeces urine, feed and feed residue were collected daily for the analysis to work out the digestibility coefficients of the proximate principles and the balances of nitrogen, calcium and phosphorus. The usual procedures for analysis were employed.

Experimental Findings and Discussion

For depicting a better comparison, the results of first balance trial which was carried out on the same animals on Jowar without any supplementation have also been included in the discussion.

Chemical Composition of Jowar Fodder

An examination of the figures contained in Table I indicate that the composition of Jowar fodder remained quite similar in the two trials except in respect of the percentages of crude fibre, total ash and phosphorus which have slightly increased at the time of the second trial. This difference in composition may be ascribed to the advance stage of maturity of the Jowar at the time of the second trial (Lakke Gowda, 1951).

Table I Showing the chemical composition of Jowar fodder during the two trials. (Percentage on dry matter basis).

Sl.No	Constituent	During I trial	During II trial
1.	Crude Protein	4107	4.001
2.	Ether Extract	1637	1.454
3.	Crude Fibre	32930	40.192
4.	N.F.E.	53422	45.440
5.	Organic Matter	92078	91.088
6.	Total ash	7921	8.911
7.	Calcium	0323	0.284
8.	Phosphorus	0183	0.541

Digestibility Coefficients of Different Nutrients

As presented in Table II no appreciable effect of supplementation with calcium carbonate has been found on the digestibility of the proximate principles of Jowar fodder. The digestibility of crude protein and N. F. E. have remained almost the same in the two trials.

Table II Showing the digestibility coefficients of different nutrients of Jowar

Animal No.	Digestibility Coefficient of					
	Dry matter	Org. matter	Crude Protein	E. E.	Crude fibre	N. F. E.
A	44.40	48.30	30.30	68.64	48.01	49.65
B	43.10	47.30	27.80	67.46	49.00	46.86
C	40.75	44.30	37.22	68.51	47.40	45.13
Average	42.75	46.63	31.80	68.20	48.10	47.21
Average of I trial without $CaCO_3$ supplementation	46.41	52.10	30.00	59.30	53.92	51.07

However, there has been a decline of the order of 5.47% and 5.82% in the digestibility of the organic matter and crude fibre respectively in the second trial. This may be attributed to the advance stage of maturity resulting in more lignification of the plant tissues. A slight increase in the digestibility of ether extract in the second trial may be due to higher intake of E. E. due to increased consumption of fodder (Crampton, 1956).

Balances of Different Nutrients

(A) **Nitrogen balance** :—No adverse effect of calcium supplementation has been observed upon the nitrogen utilization by the animals. On the other hand a higher retention of nitrogen is noted in the second trial which may be due to slightly increased digestibility of the crude protein.

Table III Showing the Nitrogen balance

Animal No.	N Intake in gms. perday	N. Excretion in gm. per day			Balance in gms. per day
		Faecal	Urinary	Total	
A	44.29	30.84	7.89	38.73	+5.56
B	42.76	30.84	9.46	40.30	+2.46
C	51.98	32.65	5.99	38.64	+13.43
Average	46.34	31.44	7.78	39.22	+7.12
Av. without Ca. supplementation	44.97	31.51	10.60	42.11	+2.86

(B) **Calcium Balance** :—It will be seen from Table IV that the animals which were showing negative calcium balance at an intake of 20.94 gms. of calcium per day through Jowar fodder were able to meet out their calcium requirement when the calcium intake was raised to 34.04 gms./day. This indicates that on an average

addition of 12 gms. of calcium per day through $CaCO_3$ is quite adequate for the maintenance of a 680 lb buffalo kept on Jowar fodder. To assess the minimum amount of calcium required for such supplementation further work is necessary, as the above value may also include the excess over the minimum required for maintenance, which might have been excreted out unabsorbed and thus striking equilibrium at a higher level of intake. However, the above calcium intake when expressed on the percentage of average dry matter ingested comes to 0.53% which compares well with 0.37% the percentage of calcium recommended in the ration for the cattle of the Western countries (Crampton, 1956).

Table IV : Showing the Calcium balance.

Animal No.	Calcium intake in gm/day				Ca. excretion in gm/day			Balance in gm/day
	Feed	$CaCO_3$	Water	Total	Faecal	Urinary	Total	
A	18.75	10.40	2.21	31.36	27.95	3.32	31.27	+0.09
B	18.01	13.20	2.05	33.26	30.16	3.60	33.76	—0.50
C	22.84	12.40	2.26	37.50	32.59	3.76	36.35	+1.15
Average	19.87	12.00	2.17	34.04	30,23	3.56	33.79	+0.25
Av. of I trial without calcium — Supplementation	19.91		1.03	20.94	23.34	3.54	26.88	—5.94

(C) **Phosphorus balance** :—No detrimental effect of the calcium supplementation upon the utilization of dietary phosphorus has been observed (table V). The increase in faecal excretion of phosphorus in the second trial is probably due to the higher phosphorus ingestion in the second trial as compared to the first trial.

Table V. Showing the Phosphorus balance.

Animal No.	P. Intake in gms/day	P. Excretion gms in gms/day			Balance in gms/day
		Faecal	Urinary	Total	
A	37.85	31.15	0.20	31.35	+650
B	34.86	31.37	0.23	31.60	+3.26
C	43.07	32.78	0.16	32.94	+10.13
Average.	38.59	31.73	0.20	31.93	+6.66
Average of the I Trial. without Ca. Supplementation	12.21	7.82	0.26	8.08	+4.13

Digestible nutrients and various nutritional indices of Jowar fodder :—

On the basis of the detailed chemical composition of Jowar fodder (Table I) and the digestibility coefficients (Table II), the percentage of various digestible

nutrients and various nutritional indices have been calculated and presented in Table VI.

Table VI. Showing the percentage of digestible nutrients and the various nutritional indices of Jowar fodder in the two trials.

Trial No	Percentage on dry matter basis							
	D. C. P.	Dig. E.E.	Dig. Crude fibre.	Dig N.F.E.	T. D. N.	S. E.	N. R.	Ca : P
I Trial without Ca. Supplementation.	1.23	0.95	17.75	27.28	48.42	21.91	1 : 31	4 : 1
II Trial with Ca Supplementation	1.27	0.69	19.33	21.55	44.28	20.21	1 : 33.1	1.2 :

It will be noted from the above table that the values for T. D. N. and S. E. have declined in the II Trial. Decreased digestibility of carbohydrate fraction due to the increase in the percentage of crude fibre on account of the advanced stage of maturity of the fodder used in the II Trial is probably responsible for this reduction in T. D. N. and S. E. values.

SUMMARY

Although Jowar as a fodder is highly nutritious, it has been reported to be deficient in respect of calcium when used as a single maintenance feed for buffaloes. As such an endevour was made to correct this deficiency through the supplementation of Jowar with $CaCO_3$. For this, balance studies were conducted on three male buffaloes fed on Jowar fodder supplemented with $CaCO_3$. No detrimental effect of Ca supplementation upon the digestibility and utilization of different nutrients of Jowar fodder has been observed. An addition of 12 gms. of Ca/day as $CaCo_3$ has been found to the quite liberal to meet out the maintenance requirement of a 680 Lb. buffalo kept on Jowar fodder alone.

Thus these studies suggest that supplementation of this valuable single feed ration with $CaCo_3$ makes it adequate to meet out the maintenance requirement of adult male buffaloes in respect of protein, calcium and phosphorus.

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EMBRYOLOGICAL STUDIES IN PSAMMOGETON BITERNATUM EDGEW.*

J. S. Dhakre,

Psammogeton biternatum Edgew is a member of the Umbelliferae. It is a xerophytic weed common in Agra. The genus grows wild in the dry regions of west Asia. In India it is found growing frequently in the plains of Punjab and in the western districts of Uttar Pradesh ascending the Himalayas to 3000 ft. above sea level.

Microsporogenesis

Three or four hypodermal archesporial cells differentiate in each lobe of the anther as seen in a cross section. A periclinal division of these cells results in the formation of a primary parietal layer and a primary sporogenous layer. The cells of the parietal layer undergo both periclinal and anticlinal divisions giving rise to a number of layers of cells which differentiate to form an endothecium, a middle layer and a single layered tapetum. The tapetum is glandular and its cells are binucleate.

The primary sporogenous cells give rise to microspore mother cells. As a result of meiotic divisions each microspore mother cell becomes tetranucleate. Cytokinesis by furrowing results in the formation of tetrahedral or isobilateral tetrads. The pollen grains are tricolpate with three germ pores and are shed at the three celled stage.

Megasporogenesis

Two ovules are differentiated in each loculus of the ovary of a young gynoecium, of which the upper one degenerates early leaving the lower to develop further. The ovules are pendulous, anatropous and unitegmic with a massive integument. The innermost integumentary layer surrounding the nucellus, forms the integumentary tapetum.

The tenuinucellate ovule shows a single celled archesporium which directly functions as megaspore mother cell. A linear tetrad is formed as the magaspore mother cell undergoes the meiotic divisions. The upper three megaspores of the tetrad degenerate, while the chalazal one develops further. The development of female gametophyte follows the Polygonum type. Thus the eight nucleate embryosac, soon, starts organising into an egg apparatus, two polar nuclei and

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*Syn. 1. *Psammogeton crinitum*, Bioss. Fl, Orient. ii, 1078.

2. *Pimpinella crintum*, Bioss, in Abb. Sc. 3rd Ser. 1, 131.

three antipodals. The antipodal cells are ephemeral and hence the mature embryo sac contains an egg apparatus and a secondary nucleus.

Endosperm

The endosperm nucleus undergoes free nuclear divisions so that a large number of nuclei are formed which line up the embryo sac wall, leaving a prominent vacuole in the centre. A number of cytoplasmic nodules or vesicles are seen to develop in the micropylar part of this endosperm. These nodules are enucleate and are fewer in number in the beginning. But as the primary protuberances (nodules) fuse with each other, other secondary nodules are developed from them. The process of fresh nodule formation continues until whole of the central space of embryosac is filled up with the cytoplasm. By this time number of endosperm nuclei is increased considerably and the cell wall formation progresses from the micropylar end of the embryosac towards the chalazal one. Finally whole of the endosperm forms the cellular tissue. The endosperm cells are rich in oil.

Fruit

The fruit is a cremocarp with five primary and four secondary ridges and six oil canals in each of the two mericarps. The ridges bear long unicellular, hooked hairs facilitating the dispersal by animals. The pericarp of the fruit is divisible in two zones—the outer mesophyllous and inner parenchymatus. The seed coat is one layered and derived from the epidermis of the integument.

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STUDIES ON THE HABITS OF COMMON YELLOW WASP-*POLISTES HEBRAEUS* FABR.

Part I. COMB

R. D. Saksena.

Introduction

The social organisation of insects, specially bees, ants and wasps, has always been a subject of very great interest to entomologists but hardly adequate information is available on the ways and behaviour of yellow-wasp—*Polistes hebraeus*. Lefroy (1919), Ayyar (1923), Hayward (1932), Duncan (1939) and Cumber (1949), are some of the important workers, who have contributed towards the study of wasps. In the following lines the author has confined his studies to the most commonly occurring yellow wasp—*Polistes hebraeus* Fabr.

Combs.

The combs of *Polistes hebraeus* Fabr. are generally found in protected out-of-the-way places like verandahs, roof-beams or on the lower side of the eaves, cornices, high ventilators or overhanging rocks, under projected portions of buildings, window-sills or electric wire coverings or in the corners of the walls. Sometimes, they build over trees, close to human habitations probably for the advantage of receiving an easy supply of food and water. Occasionally they select 'Neem' trees (*Azadirachta indica*) for this purpose, as these are very shady and generally free from other insects, harmful to their society. The combs have, sometimes, been found in very odd places e.g. in a tin box or the boiler of an unused tractor, a deserted pigeon-hole, a tree-trunk or a shelf, close to the water tap. While building on a tree, topmost branch is preferred. Being very powerful fliers, they have been observed on the high pinnacle of buildings viz., even on the dome of the Taj, at a height of 320 ft. from the ground. Duncan (1939) corroborated by Alam (1959) holds that these wasps do not exercise any discretion towards the selection of a site in view of protection but show a definite preference for building combs at hights.

The combs are mostly circular, although oval or irregular forms are also met with. These shapes help in maintaining their balance. The size differs considerably. At the end of one year a normal colony builds a comb of about 8″ in diameter, but older combs are bigger and some times they measure more than 14″ in diameter. The maximum area of a comb is about 200 sq. inches. In the beginning, one single cell is prepared by the queen which hardly occupies ·04 sq. inch of space. The comb appears grey from above but white with grey spots from below. The whitish cells are closed and contain pupae, while the grey have eggs and larvae. Often the walls

of the grey cells are further prolonged by depositing new pulp, which has a pale white colour and sometimes after this, new portions also become grey and merge into the older ones.

In small combs there is generally one thick stout middle stalk which is cemented to the substratum (Plate 1, Figs. 1,2,3 & 7). No sooner the central cells are deserted owing to use and age, and new ones added on the periphery without disturbing the balance of the entire comb, a necessity may arise for providing new subsidiary stalks for maintaining the horizontal position of the comb. In multi-stalked combs the central stalk is the stoutest and the biggest. The size of the stalk depends upon the size of the comb, but the longest stalk is never more than 2". The stalk always hangs vertically to its place of attachment carrying the nest at the other end, but seldom, horizontal right-angled bent stalks, which do not occupy the central position on the comb, have also been noticed. The area for holding the stalk on the substratum is always greater than that actually occupied, because prepared foundation for putting the subsidiary stalks would be instantly available.

The comb generally has a convex upper surface (Plate 1, Fig. 7), seldom plain, covered by a thick coat of dark grey water-proof pulp resembling the material of which the stalk is made. Such a nest although built in perfectly open place, exposed to heat, is perfectly safe. The lower surface is generally concave as the cells at the periphery descend lower than the central ones. Occasionally a small patch of central pale white cells also grows longer and clearly marks the old from the new material. These new cells which are perfectly round and broader at their openings than at their bases, form the pupal chamber for the next brood. The rest of the cells appear to be hexagonal owing to the pressure of the walls of the adjacent six cells (Fig. 5) which surround each other. The cells in the centre are generally smaller, 50 cells per sq. inch than those at the periphery, 25 cells per sq. inch and perfectly vertical, while the peripheral ones tend to become horizontal forming oblique canals. The cells underneath the stalk are always the smallest about 3 mm. in diameter if they are not in two tiers.

Some of the cells, a few in the centre and some round the periphery, possess double tiers owing to the addition of fresh walls of new material (Fig. 7). The openings of the cells of the first tiers are closed by means of downwardly convex opercula of paper and the walls of the same are further extended to form a new storey lower than the previous one (Figs. 4 and 7). It is interesting to note that each cell has its own wall, (Fig. 6) consequently, a wall in between two adjacent cells can be split up into two by removing the glue.

Polistes prepares its nest without any gymnodom. The cell-wall is made up of thin fibres of cellulose intermeshed with each other with a thin transparent matrix. The material used is a vegetable matter, like woodfibres chewed with saliva and converted into paper pulp insoluble in water and dilute acids. Old and

soft wood, softened by the action of weather, is generally preferred, although Alam (1959) believes that wasps prefer old and seasoned wood. The roof of the nest is made more resistant than any other part. The mandibles working in an inward and outward direction scrape off wood-fibres, even from living cortex (Alam 1959), which are moistened, finely chewed, rolled into small balls and deposited over the nest by means of fore legs and mandibles and thus converted into thin strips. The colour of the comb mainly depends on the material, fibres of which go to make the comb, generally it is greyish brown but pale yellow in the freshly constructed cells. The size of a comb depends upon its life. The average diameter of a single cell is 7-8 millimeters.

Horne observes that the tops of the cells of the queen wasps are lined with silk and these insects use some sort of glutin to temper the paper and to solidify the silken cell covering, but no silken fibre has been noticed in the cell material in the combs of the *Polistes hebraeus* Fabr.

COMB-BUILDING

Wasps generally start building their combs early in March if it is warm, otherwise in April when most of the queens can be seen flying about in search of suitable places for founding their colonies. Usually each over-wintered-fertilized queen starts her work independently, although on rare occasions, more than one queen have also been noticed working on the same nest. To find many egg-laying females in a full colony, is not very uncommon but establishment of a new colony by more than one mature female is extremely rare. After selecting a suitable place, the queen spreads out a layer of salivary secretion with which it makes a few wood-fibres to stick. The mass becomes very hard when dry and this forms the base from which a stalk or peduncle hangs vertically downwards by further deposition of the papery pulp. At the end of this small stalk is then built a small cell of not more than 2 millimeters in diameter. A second cell is then added (Fig. 1.) The first cell and the stalk are generally formed in one day. The operation has been noticed to be carried out in less than 8 hours in certain rare cases. The queen lays a tiny egg as soon as the cell is ready, but occasionally eggs are laid when a number of cells have been constructed. In about 3 days time, six cells have been constructed round the first cell which occupies the central position. Thus the whole nest has now 7 cells. Ovi-position takes place irregularly and each cell may contain an egg. More time is now spent in enlarging these cells than in adding new ones to the comb. The female herself guards the small nest and keeps clinging to it. She rests motionless and seldom goes out to bring pulp or to collect food material. After about a week, further cells are added and in about a month's time it comes to possess about 15 cells. The time taken to build the comb and the number of cells, differ according to the availability of material. In about 10 days time, the eggs hatch into larvae, although the incubation pariod depends upon the rate of feeding. Generally only one egg is deposited

in one cell, although the author has noticed upto a maxium of 3 eggs per cell. They are attached to the angle, formed by the meeting of two walls-of the hexagon and quite close to the base of the cell. The egg possesses a tapering conical end by which it is attached to the wall. The other end is always round. The queen, later on, spends most of the time in feeding the larvae. This duty of enlarging the nest is mainly performed by the first progeny, consisting mostly of workers. In older combs of European species of *Polistes*, Mayer has observed that older wasps fly out in quest of the nest-building material, and bring it to the younger ones which remain in the nest to receive the loads brought in and to enlarge the nest. The absence of the queen or stem-mother does not disturb the workers and they carry on their duties peacefully.

Marchal and Janet have observed that warmth is of utmost importance to the nests of *Vespa*, hence a particular temperature is maintained within the nest, which is essential for the development of individuals. The presence of a gymnodom round the nest of vespa is helpful in maintaining the temperature. Since no such covering exists round the *Polistes'* comb, the temperature of the nest in general is not very far above that of the atmosphere, although the temperature, of the hornet nest, according to these authors, was 12° higher, when the outside temperature measured 20°c. Maintenance of warmth has been noticed in the nest of *Polistes* during winters, and the heat is probably retained in the nest due to the paper which is a bad conductor. Undoubtedly, they have a greater power of adaptability under different climatic conditions and this is probably the reason for the universal occurrence of these insects and their relatively greater richness in species in the tropics.

It is difficult to distinguish the cells of the queen from those of other forms in the nest of *Polistes* except that the pupal chambers are prominent because they are closed by operculae. Originally they were larval chambers, but closed immediately before pupation. This probably helps in retaining heat within the chamber.

The cells, once occupied by larvae or pupae, are not used again immediately after they are vacated. The next progeny is deposited in a circle round the central cells which were initially utilised for the same purpose. The third progeny is either laid in cells round the first ring or in the cells used in the first deposition, which are closed and their walls are enlarged to form a second tier of cells. The author has not been able to find more than two tiers even in very old nests. When the cells of such an old nest become unserviceable, new cells are either added and the whole nest is expanded beyond and new stalks put in here and there as subsidiary supports, or the entire comb is deserted *in toto* and a new one is established, generally close by. It is very doubtful if a deserted comb is ever re-inhabited by new queens of *Polistes habraeus* Fabr. even under most adverse circumstances. According to Isety, however, several queens undertake the repairs of an old nest of the previous year in American *Polistes rhetricus*. In this species nest-founding by the

Fig. 1

Fig. 2

Fig. 3

Fig. 4

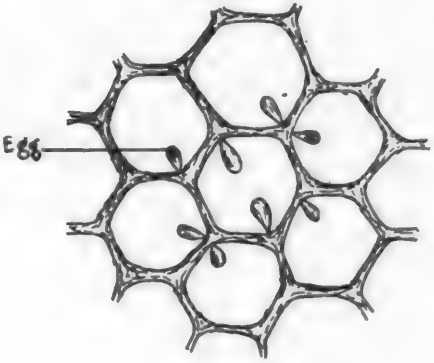

Fig. 5

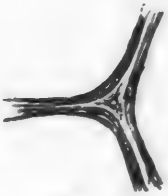

Fig. 6

Fig. 7

PLATE I

Fig. 1. A view of two-celled comb.
Fig. 2. A small comb with a horizontal stalk.
Fig. 3. A small comb with a vertical stalk.
Fig. 4. Two double-tiered cells dissected.
Fig. 5. Diagrammatic view of cells with attachment of eggs to the corner.
Fig. 6. A section to show the separate walls of two adjacent cells.
Fig. 7. A full sized comb showing cells in single and double tiers.

common labour of many females, is also observed. The European species of *Polistes* also exhibits this phenomenon. In the species in question, the nest is founded by queens independently, although later on two or more individuals may combine their labour to enlarge a nest.

SUMMARY

1. Combs of *Polistes* are found in odd places, at hights and near water.
2. Cells in the comb may be in a single tier but never more than double, depending upon the age of the comb.
3. Each cell has an independent cell-wall and the hexagonal shape is due to pressure exerted by walls of six adjacent cells.
4. Stalks, one or several, are always vertical, rarely horizontal.
5. Wood fibres obtained from dead and living plants, chewed with saliva, form the paper-pulp used in building combs.
6. Generally a single egg and rarely upto a maximum of three eggs are glued to the inner angles in a cell.
7. A temperature higher than atmosphere is maintained in the nest for development of larvae.

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CHAETOTAXY OF THE MATURE LARVA OF PIERIS BRASSICAE L. (LEP. : PIERIDAE)

G. P. Mukerji

Introduction.

Apart from the broad morphological studies of the insect larvae the chaetotaxy is of greater importance specially in the case of lepidopterans. Different authors have given the morphological description of some of the lepidoterous larvae viz. Gardner (1938, '41, '42 and '44), Sevastopalo (1944, '45 and '48) and Singh (1953). But the description of the seate is generally neglected although interesting and rather important from the taxonomic stand point.

The chaetotaxy has been a source of great controversy and various often confusing diffenent names have been suggested for the same setae. To avoid this confusion, nomenculature suggested by Hinton (1946), which is very commonly employed these days, has been followed in the present work. The author has tried to give a complete account of the setae present on the body of the final or fifth instar larva of *pieris brassicae* L. in this paper.

Technique.

For the study of the setae the final instar larvae of *pieris brassicae* preserved as well as fresh were examined. To avoid error and abnormality the conclusions were based or an average of a good number of specimen. The larvae were examined carefully under a binocular and care was taken, not to damage the setae. To confirm the existance of the smaller setae, the body-wall from different segment was mounted and studied under high power.

Chaetotaxy.

(i) General :—The final instar larva of *Pieris brassicae* is a well-built cylindrical dark brown or blakish caterpillar with an almost triangular head, hypognathous mouth-parts and elongated body. On the head the setae are located mostly near the sutures and the antennae, rest of the spaces being devoid of them. The thoracic segments bear the setae symmetricaly placed on all the segment viz. prothorax, mesothorax and the metathorax except that of the cervical shield on the pro-thorax. A heavily chitinized, dark coloured, plate like cervical shield bearing 4 setae is present at the mid-dorsal region of the pro-thorax The said 4 setae are named according to the nomenculature of Hinton. In the abdominal region, same number of setae are present at similar positions in the subsequent segments except that of the posterior most region where the number, position and size of the setae differs, (Plate I; Figs. 1-5 and Plate II, Fig. 1).

(ii) Head. Ocellar region with O_1, O_2 ; SO_1, SO_2 and SO_3 present (Plate 1, Fig. 2). The frons with F_1 and F_2 ; clypeus with C_1, C_2 and C_3 (Plate 1 Fig 4). Area between the ocellar region and the clypeo-laberal margin with A_1, A_2 and A_3 ; parietal region posterior to A_1 and A_2 with P_1 and P_2 ; postero-dorsally ocellar region with a prominent L_1 (Plate I, Fig. 4).

(iii) Thorax. Prothorax with XD_1, XD_2; D_1; SD_1 ; L_1, L_2 ; SV_1, SV_2, SV_3, SV_4 and MV_3 (Plate II, Fig. 1). L_1, L_2 ; SV_1, SV_2, SV_3 and SV_4 are borne on small chitinized pieces in pairs (Plate II, Fig. 1, T_1). Meso and Meta-thorax with D_1, SD_1; L_1, L_2, L_3 and SV_3 present (Plate II, Fig. 1 T_2 and $_3$).

(iv) Abdomen. First and second abdominal segment with D_1 ; SD_1 ; L_1, L_2 SV_1, SV_2, SV_3 ; V_1 and V_2 (Plate II, Fig. 1, A_1 and $_2$). Third fourth fifth and sixth abdominal segments with D_1, SD_1 ; L_1, L_2 ; SV_1 and SV_2 only Plate II, Fig. 1, A_{3-6}). Seventh abdominal segment with D_1, SD_1 ; L_1, L_3 ; SV_1, SV_2 ; V_1 and V_2 (Plate II, Fig 1, A_7). Eighth abdominal segment with D_1, D_2 ; L_1, L_2 ; SV_1, SV_2, SV_3 and V_1 (Plate II, Fig 1, A_8) Ninth abdominal segment with D_1, D_2 ; L_1 ; SV_2, SV_3 and V_1 (Plate II, F g 1, A_9). Tenth abdominal segment with XD_1, XD_2 ; D_1 and D_2 only (Plate II, Fig. 1, A_{10})

It would be apparant from the above description that first, second, eighth and ninth abdominal segments which do not bear prolegs are provided with ventral setae where as the remaining segments with the pro-legs are devoid of the ventrals. The larvae of *P. brassicae* L. bear two types of setae which has been termed by Hinton (1946) as Pro-prioceptor (or microscopic) and tactile (or long) setae. The microscopic setae are normally found at the anterior margin of the thoracic and abdominal segments, and come in contact with the segment infront or may be concealed entirely by it when there is a retraction of one segment into the other ; such as usually accompanies most normal movement of the larvae. The symbol for this group of setae is preceeded by a capital 'M' Hinton (1946), (Plate II Fig. 1 MV_3)

Summary.

1. The final instar larva of *Pieris brassicae L.* has small sized setae almost uniformly distributed over its body.
2. On the head region setae are mostly located near the sutures and near the antinnae.
3. Prothorax differs from the meso and meta thorax in having the mid-dorsal cervical shield and few other setae on small oval, chitinized patches.
4. Meso and metathorax resemble each other and have lesser number of setae than the pro-thorax.
5. First two abdominal regments differ in only the ventrals being absent in the second segment.
6. Pro-leg bearing segments all resemble each other and have fewer number of setae.
7. Seventh and eighth abdominal segments resemble the first and have the ventrals.

8. Ninth segment in the abdomen has the ventral but has fewer setae.
9. Posterior most segment has the setae only on the anal shield, rest of the setae including the ventrals are absent.

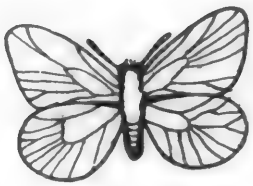
TABLE

Table showing the number and region of the setae along with the Hinton's nomenculature.

No.	Region	Seta	Hinton's Nomenculature	Total setae
1.	Head	Ommatalis	O_1	2
2.			O_2	
3.		Sub-ommatalis	SO_1	3
4.			SO_2	
5.			SO_3	
6.		Frontalis	F_1	2
7.			F_2	
8.		Clypealis	C_1	3
9.			C_2	
10.			C_3	
11.		Anteriores	A_1	3
12.			A_2	
13.			A_3	
14.		Posteriores	P_1	2
15.			P_2	
16.	Head	Laterais	L_1	3
17.	Thorax &		L_2	
18.	Abdomen		L_3	
19.	Thorax	Mic.–ventralis	MV_3	1
20.	Thorax &	Dorsalis	D_1	2
21.	Abdomen		D_2	
22.		Sub-dorsalis	DS_1	1
23.		Sub-ventralis	SV_1	4
24.			SV_2	
25.			SV_3	
26.			SV_4	
27.		Anteriors dorsalis	XD_1	2
28.			XD_2	
29.	Abdomen	Ventralis	V_1	2
30.	Only		V_2	

Total number of setae on each lateral half is—30

PLATE I



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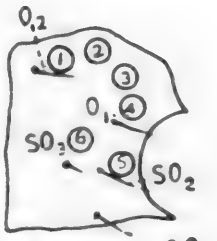

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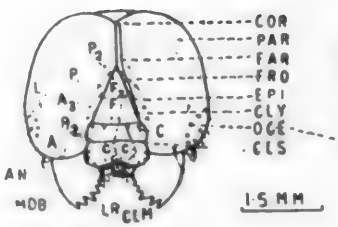

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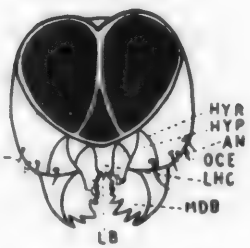

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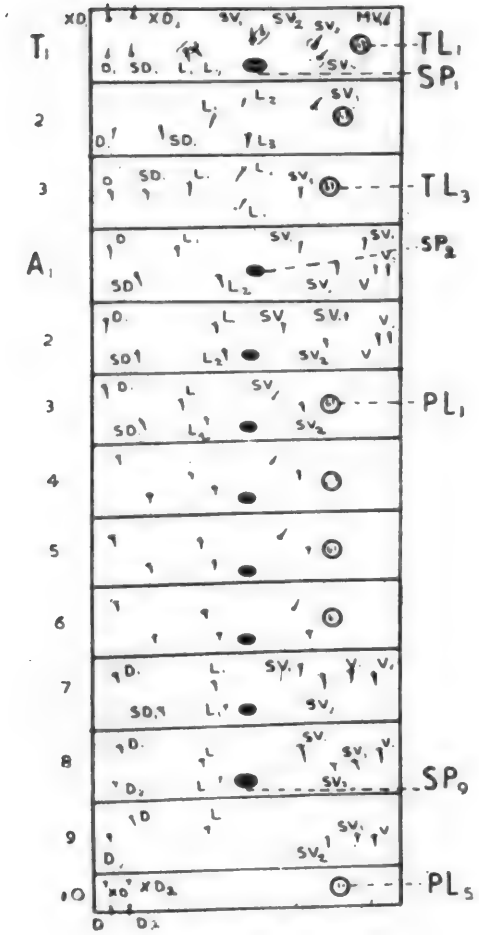
PLATE II



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BLOCK PLATE

Abbreviations

Plate I
Fig. 1
Mature butterfly *P. brassicae* L
Fig. 2
Ocelar region of the larva.
1–6—First to Sixth Ocellus
O_1—Ommatalis prima
O_2— ,, secunda
SO_1—Sub-ommatalis prima
SO_2— ,, ,, secunda
SO_3— ,, ,, tertia
Fig. 3
Fifth instar larva of *P. brassicae* L.
Fig. 4
Head of the larva (Dorsal view)
Fig. 5
Head of the larva (veatral view)
A_1—Anteriores prima
A_2— ,, secunda
A_3— ,, tertia
AN—Antenna
C_1—Clypealis prima
C_2— ,, secunda
C_3— ,, tertia
CLM—Clypeo-labral membrane
CLS— ,, ,, suture
CLY—Clypeus
COR—Coronal suture

EPI—Epistomal suture
F_1—Frontalis prima
F_2— ,, secunda
FAR—Frontal arms
FRO—Frons
HYP—Hypostoma
HYR—Hypostomal ridge
L_1—Lateralis prima
LHC—Labio-hypopharyngeal complex
LR—Labrum
MDB—Mandible
OCE—Ocelli
P_1—Posteriores prima
P_2— ,, secunda
PAR—Parietal

Plate II

Fig. *1*

Diagramatic diagram of the setae on the lateral half of the body of the mature larva of *P. brassicae L.*

A_1—10—First to tenth abdominal segment of the larva.
D_1—Dorsalis prima
D_2— ,, secunda
L_1—Lateralis prima
L_2— ,, secunda
L_3— ,, tertia
MV_3—Microscopic ventralis tertia
PL_1-PL_5—First to fifth pro-leg of the larva.
SD_1—Sub-dorsalis prima.
SP_1-SP_9—First to ninth spiracle
SV_1—Sub-ventralis prima
SV_2— ,, ,, secunda
SV_3— ,, ,, tertia
SV_4— ,, ,, quadra
T_1-T_3—First to third theoracic segment
TL_1-TL_3—First to third thoracic leg.
V_1—Ventralis prima
V_2— ,, secunda
XD_1—Mid dorsalis prima
XD_2—Mid dorsalis secunda

NOTES

A LIST OF THESES SUBMITTED TO THE AGRA UNIVERSITY THROUGH THE B.R. COLLEGE IN 'HORTICULTURE'

(Till 1960)

CLASSIFICATION OF THE THESES

(At post graduate level)

Class No.	Title of the class	No. of theses written
	Pomology.	
I.	Propagation by cutting.	21
II.	Propagation by layering.	2
III.	Propagation by budding.	8
IV.	Manuring of citrus trees.	4
V.	Set and drop of citrus fruits.	4
VI.	Induction of parthenocarpy and seedlessness in fruits.	1
VII.	Storage of fruits.	3
	Olericulture.	
A.	Potato	21
B.	Tomato	6
C.	Pea	2
D.	Onion	4
E.	Garlic	1
F.	Radish	2
G.	Turnip	3
H.	Carrot	2
I.	Brinjal	1
J.	Cauliflower	6
K.	Cabbage	2
L.	Lettuce	2
M.	Sweet potato	1
N.	Okra	1
O.	Tinda	2
P.	Cumin	1
Q.	Watermelon	1
	Floriculture.	
	Cultural treaments on perennial chrysanthemum.	1
		(At Ph. D. level)
1.	Citrus cuttings.	1

The details of the theses are given in the following pages

S. N.	Title of theses	Year
	POMOLOGY	
	I. Vegetative propagation of fruit plants by cuttings :—	
	A. Citrus :	
	1. Limes (*Citrus aurantifolia* Linn.)	
1.	Studies into the effects of naphthalene acetic acid (NAA) at six concentrations and three durations of immersion by dilute solution method on the performance of sweet lime cuttings.	1951
2.	Effect of β-indole acetic acid (IAA) at four concentrations on the rooting and shoot growth of sweet and kagzi lime cuttings.	1956
3.	Effects of β-indole acetic acid (IAA) and indole-3-butyric acid (IBA) on the rooting and shoot growth of kagzi lime cuttings.	1957
4.	Effects of IAA and IBA at different concentrations on the rooting of two types of sweet lime cuttings.	1957
5.	Effect of different concentrations of IBA and Seradix powders on the performance of sweet & kagzi lime cuttings.	1958
6.	Influence of source and planting environment on the performance of softwood cuttings of kagzi lime.	1958
7.	Studies into the effects of harmone treatment and different intervals between ringing and planting on hardwood cuttings of kagzi lime (*Citrus aurantifolia* Swingle).	1959
8.	Effect of time, environment of planting and source on the performance of soft wood cuttings of kagzi line (*Citrus aurantifolia* Swingle).	1960
9.	Studies into the effects of source, planting time and concentrations of Indole -3- butyric acid on the performance of semi-hard-wood cuttings of sweet lime (*Citrus limettioides* Tanaka)	1960

S. N.	Title of theses	Year
	ii. Khatta (*Cirtus karna*)	
10.	The effect of IAA in its varying concentrations and periods of immersion on the rooting response of khatta cuttings.	1951
11.	The effect of IBA at three concentrations and three durations of immersion on the root and shoot growth of khatta.	1951
12.	Influence of time of planting and harmone application on the performance of hard and semi-hardwood cuttings of Karna Khatta (*Citrus karna* Ref.)	1959
	B. Mulberry—White mulberry (*Morus alba* L) **and red mulberry** (*Morus nigra* L) :	
13.	Rooting response of white and red mulberry cuttings to the application of IBA. NAA and a 50 : 50 mixture of the two, used at different concetrations by dilute solution method.	1955
14.	Studies on the effects of IAA, NAA and a 50 : 50 mixture of the two used at four concentrations on the performance of two varieties of mulberry cuttings.	1955
15.	Experimental studies into the response of two varieties of mulberry cuttings to the application of IBA, NAA and a 50 : 50 mixture of the two at four concentrations	1956
16.	Effect of IBA, NAA and their mixture (50 : 50) at four concentrations on the performance of two varieties of mulberry cuttings.	1956
17.	Studies on the effects of source, type and dates of planting on the performance of stem cuttings of white mulberry (*Morus alba* Linn.)	1959
	C. Karonda (*Carissa carandas* L) :	
18.	Influence of source of cuttings and times of planting on the performance of hardwood cuttings of *Carissa carandas*.	1958

S. N.	Title of theses	Year
19.	Studies into the effects of different concentrations of IBA applied by concentrated dip method and also of Seradix powder on semi-hardwood and hardwood cuttings of *Carissa carandas*.	1958
20.	Influence of planting date and harmone concentration on hard-wood cuttings of Karonda (*Carissa carandas* Linn).	1959
	D. Guave (*Psidium guajava* L.)	
21.	Studies into the effects of time, environment of planting and source on the performance of soft wood cuttings of guava (*Psidium guajava* L.)	1960
	II. Vegetative propagation of fruit plants by layering.	
	A. Mango (*Mangifera indica* Linn.):	
1.	Studies into the effects of media, plant regulators and their concentrations or air layering in Mango (*Mangifera indica* Linn)	1960
2.	Effect of plant regulator, age of shoot and time of operation on air layering in mango (*Mangifera indica* Linn.).	1960
	III. Vegetative propagation of fruit plants by budding:	
	A. Citrus—Malta and mosambi (*C. sinencis* Osbeck.) and Grape fruit (*C. paradisi* Macf.):	
1.	The effect of different forms of manure, levels of nitrogen and intervals of irrigation on the growth of khatta stocks and on the success of budding of Malta.	1951
2.	The effect of different dates of budding and lopping of the stock on the success of budding of Malta on khatta.	1951
3.	The effect of different dates of budding and methods of heading back of the stock on the budding of Mosambi on khatta stocks.	1951
4.	The effect of season, time of budding and lopping on the budding of Mosambi on khatta stocks.	1952

S. N.	Title of theses	Year
5.	Effect of types of bud and dates of lopping on the budding of grapefruit and Mosambi on khatta stocks.	1956
6.	Effect of types of bud and dates of lopping on the budding of Mosambi and grapefruit on khatta stock.	1957
7.	Response of different types of scion buds of grapefruit budded on khatta to different concentrations of IAA and IBA.	1957
	B. Mango (*Mangifera indica* L.) :	
8.	Studies into the effects of age of stock, season and methods of budding on the performance of vegetative propagation of Mango.	1951
	IV. Manuring of Citrus trees :	
	i. **Mosambi** (*Citrus sinensis* Osbeck.)	
1.	Effect of two forms and four levels of nitrogen on the performance of Mosambi.	1952
	ii. **Grapefruit** (*Citrus paradisi* Macf.)	
2.	Effect of N, P and K singly and in combination on the perfromance of grapefruit.	1952
3.	Effect of N, P and K singly and in combination on the performance of grapefruit.	1953
	iii. **Kagzi-lime** (*Citrus aurantifolia* Swingle)	
4.	Effect of different doses and kinds of organic and inorganic nitrogen on growth, set, drop and devolopment of kagzi-lime fruits.	1952
	V. Set and drop of Citrus fruits :	
	i. **Kagzi lime** (*Citrus aurantifolia* Swingle.)	
1.	Bearing habits of kagzi lime and the effect of different concentrations of NAA sprayed at four different times on set and drop of kagzi lime.	1951

S. N.	Title of theses	Year
2.	The effect of 2, 4–D on fruit set and pre-harvest drop of kagzi lime.	1951
3.	The effect of NAA and 2, 4–D on the set and drop of kagzi lime fruits.	1952
	ii. **Mosambi** (*Citrus sinensis* Osbeck.)	
4.	Effect of organic and inorganic forms of nitrogen on the fruit set and fruit drop, and the development and growth of Mosambi plants.	1951
VI.	**Induction of parthenocarpy and seedlessness in fruits :**	
	Guava (*Psidium guajava* L.)	
1.	Studies into the bearing habits of guava, and the effect of IAA, IBA and NAA on the development and seedlessness of its fruits	1951
VII.	**Storage of fruits :**	
	A **Citrus :**	
	i. **Santra** (*Citrus reticulata* Blanco.)	
1.	Effect of varying temperature and wrappers on the changes taking place in the physical and chemical characteristics and the keeping quality of santra.	1951
	ii. **Mosambi and Malta** (*Citrus sinensis* Osbeck.)	
2.	Effects of variation in stage of harvest and storage temperature on the storage life and quality of Mosambi and Malta.	1956
	B. Mango (*Mangifera indica* L.)	
3.	Studies into the effect of temperature of storage life, keeping quality and chemical composition of three varieties of mango.	1951
	OLERICULTURE	
	A. **Potato** (*Solanum tuberosum* L.) :	
	i. **Dates of sowing and variety.**	

S. N.	Title of theses	Year
1.	Investigation on the effects of four dates of swing on the tuberisation, yield and quality of the produce and the economics of the crop of four varieties of potato.	1955
2.	Studies into the response of four varieties of potato tubers to variations in dates of sowing in respect of growth and yield.	1955
	ii. **Method of sowing and variety.**	
3.	Effect of varieties and methods of planting on growth, yield and quality of potato	1960
	iii. **Spacing and variety**	
4.	Studies into the effects of different spacings from row to row on the tuberisation, yield and economics of four varieties of potato.	1956
5.	Response of four varieties of potato tubers to Variations in spacing between rows in respect of growth and yield.	1956
6.	Response of four varieties of potato tubers to variations in spacing between rows in respect of growth and yield.	1957
	iv. **Spacing and manuring.**	
7.	Effect of spacing and increasing levels of nitrogen on the growth, yield and quality of potato.	1958
8.	Effect of spacing and increasing levels of nitrogen on growth, yield and quality of potato.	1959
9.	Effect of spacing and levels of nitrogen on growth, yield and quality of potato.	1960
	v. **Manuring.**	
10.	Effect of nitrogen, phosphorus and potash, each at three levels, singly and in combination on potato.	1951
11.	Effect of N, P and K applied singly and in combination at different levels on growth, development and yield of Phulwa potato	1953

S. N.	Title of theses	Year
12.	Effect of organic and inorganic forms of nitrogen with and without the basal dressing of P_2O_5 on the growth, development and yield of Patna Phulwa Potato.	1955
13.	Effect of two forms of inorganic nitrogen with three times of application on Patna Phulwa potato.	1955
14.	Effect of two forms of inorganic nitrogen with three times of application on Patna Phulwa potato.	1957
	vi. **Culture.**	
15.	Effect of three grades of seed potato, two methods of sowing and two forms of manure on growth, development and yield of Gola potato.	1951
16.	Effect of earthing and mulching on the growth, yield and quality of Phulwa variety of potato.	1954
17.	Studies into the effects of earthing and mulching on the growth, yield and quality of Phulwa variety of potato.	1955
	vii. **Storage.**	
18.	Effect of cold storage period on the germination and growth of three varieties of potato.	1952
19.	Effect of types of tuber with respect to the degree of sprouting and the interval between removal from the cold storage and sowing on germination, growth and yield of local Phulwa potato.	1952
20.	Effect of after-cold-storage duration and size of tubers on growth and yield of Red Patna and Patna Phulwa potato.	1953
21.	Investigation on the effects of dates of sowing after removal from cold storage and size of seed tubers on two varieties of potato.	1953
	B. **Tomato** (*Lycopersicon esculentum* Mill.) :	
	i. **Manuring.**	
22.	Effect of N, P and K at different levels singly and in combination on growth, yield and quality of tomato.	1951

S. N.	Title of theses	Year
23.	Effect of N, P and K singly and in combination on the composition of tomato fruits.	1951
	ii. **Interculture:**	
24.	Effect of spacing, staking and pruning on the chemical composition of tomato.	1951
25.	Effect of different types of pruning, staking and distance of planting on the growth and yield of tomato.	1952
	iii. **Parthenocarpy.**	
26.	Studies into the effects of IAA, IBA and NAA applied by different methods to the development of parthenocarpy in tomato fruits.	1951
27.	Production of seedless fruits in tomato by the application of IBA and NAA at five concentrations.	1952
	C. **Pea** (*Pisum sativum* L.) :	
	i. **Culture.**	
28.	Effect of different dates of sowing and staking on germination, growth, yield and quality of garden pea.	1953
	ii. **Vernalisation.**	
29.	Vernalization response in relation to the yield of green pods in two varieties of garden pea.	1951
	D. **Onion** (*Allium cepa* L.):	
	Manuring.	
30.	Effect of nitrogen and phosphorus at four levels, singly and in combination on growth, yield and quality of onion	1952
31.	Effect of three levels of nitrogen and three intervals of water supply on growth, yield and quality of onion.	1953
32.	Effect of increasing levels of nitrogen in two inorganic forms on the growth, yield and quality of onion.	1954

S. N.	Title of Theses	Year
33.	Studies into the effects of forms and levels of inorganic nitrogen on growth, yield and quality of onion (*Allium cepa* L.).	1960
	E. Garlic (*Allium sativum* L.)	
	Method of culture.	
34.	Effect of three times and two methods of sowing under three spacings on germination, growth, yield and quality of garlic.	1952
	F. Radish (*Raphanus sativus* L.) :	
	Manuring and spacing.	
35.	Effect of N, P and K each at three levels, singly and in combination on the growth and yield of radish.	1951
36.	Effect of different levels of nitrogen and spacing on the growth and yield of local long rooted white radish.	1952
	G. Turnip (*Brassica rapa* L.) :	
	Spacing and manuring.	
37.	Effect of different doses of nitrogen and spacing on the growth, development and yield of turnip.	1952
38.	Effect of different doses of organic nitrogen, dates of application and methods of planting on growth, development and yield of turnip.	1951
39.	Effect of different levels and forms of nitrogen on growth and yield of turnip.	1953
	H. Carrot (*Daucus carota* L.) :	
	Manuring and irrigation.	
40	Studies into the response of two varieties of carrot to three levels of nitrogen and three intervals of irrigation.	1951
41.	Effect of different forms and levels of nitrogen on the development and yield of carrot roots.	1953

S. N.	Title of theses	Year
	I. Brinjal (*Solanum melongena* L.) :	
	Variety and spacing.	
42.	Studies into the growth and bearing habits of six varieties of brinjal planted under two spacings.	1952
	J. Cauliflower (*Brassica oleracea* L. var. *botrytis* L.) :	
	i. Manuring and spacing.	
43.	Effects of increasing levels of nitrogen with and without $P_2 O_5$ on the growth and yield of culiflower.	1957
44.	Effects of different spacings and increasing levels of nitrogen on the growth, yield and quality of Cauliflower.	1958
45.	Effect of spacing and increasing levels of nitrogen on growth, yield and quality of cauliflower.	1959
	ii. Age and treatment of seedling.	
46.	Effects of starter solution, hardening and age of seedlings on growth, yield and quality of cauliflower (*Brassica oleracea* L. var. *botrytis*).	1959
47.	Effect of methods of hardening and time of top dressing on growth, yield and quality of cauliflower (*Brassica oleracea* L. Var. *botrytis*).	1960
48.	Effect of age of seedlings and their number per hill at transplanting on survival, growth, yield and quality of cauliflower (*Brassica oleracea* L. Var. *botrytis*).	1960
	K. Cabbage (*Brassica oleracea* L. var. *capitata* L.) :	
	i. Manuring.	
49.	Effects of five combinations of ammonium sulphate and municipal compost on two varieties of cabbage.	1952
	ii. Irrigation.	
50.	Studies into the effects of the quality of irrigation water on the growth and yield of three varieties of cabbage	1957

S N.	Title of Theses	Year
	L. Lettuce (*Lactuca sativa* L.)	
	Manuring	
51.	Effect of different forms and levels of nitrogen on the growth and yield of lettuce.	1951
52.	Effect of different forms and levels of nitrogen on the growth and yield of lettuce crop.	1952
	M. Sweet potato (*Ipomoea batatas* Lam.) :	
	Manuring.	
53.	Effect of different levels and forms of nitrogen on growth, yield and quality of sweet potato.	1954
	N. Okra (*Abelmoschus esculentus* (L.) Moench.)	
	Parthenocarpy.	
54.	Studies into the growth and bearing habit of okra and effects of IBA and NAA on the production of its fruits.	1952
	O. Tinda (*Citrullus vulgaris* Schrad. var. *fistulosus* Stocks.):	
	Parthenocarpy	
55.	Studies into the effects of plant regulators and their concentrations on parthenocarpy in tinda (*Citrullus vulgaris*, Schard Var. *fistulosus*).	1960
56.	Studies into the effects of IBA and NAA at five concentrations on the development and seedlessness of Tinda.	1958
	P. Cumin (*Cuminum cyminum* L.) :	
	Method of sowing and manuring.	
57.	Effect of increasing levels of nitrogen and methods of sowing on the growth and yield of cumin.	1957
	Q. Watermelon (*Citrullus vulgaris* Schard.)	

S. N.	Title of theses	Year
58.	Effect of plant regulators and their methods of application on parthenocarpy in watermelon (*Citrullus vulgaris* schord).	1960
	FLORICULTURE	
	Cultural treatments on perennial chrysanthemum. (*Chrysanthemum* sp.)	
1.	Effects of dates of planting and methods of training on the growth of the chrysanthemum plants and quality of the flowers.	1952

THESES AT Ph. D. LEVEL

S. N.	Title of theses	Writer	Year
1.	Studies into the effects of source, plant regulator treatment and planting environment on citrus cuttings.	R.P. Singh	1960

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